

EXCESS SILICA SUBSTITUTION IN PLAGIOCLASE GRAINS IN THE PASAMONTE EUCRITE.

D. W. Mittlefehldt¹, L. Le², and E. L. Berger³, ¹Astromaterials Research Office, NASA Johnson Space Center, Houston, TX, USA (david.w.mittlefehldt@nasa.gov), ²Jacobs JETS-NASA Johnson Space Center, Houston, TX, USA, ³GCS-Jacobs JETS-NASA Johnson Space Center, Houston, TX, USA.

Introduction: Pasamonte is a clast-rich polymict basaltic breccia [1, 2] with O- [3-5] and Cr-isotopic [6] compositions that are resolved from those of most eucrites. It is dominated by two mafic clast types: (i) very-fine- to fine-grained, variolitic, subophitic and ophitic basalts, usually containing zoned pyroxenes; and (ii) fine- to medium-grained hypidiomorphic-granular and allotriomorphic-granular microgabbros containing pyroxenes composed of augite lamellae in homogeneous pigeonite hosts [2]. Minor clast types are fine-grained impact-melt, mafic-breccia and mafic-granular clasts; coarse matrix mineral fragments include pyroxene, plagioclase, silica, ferroan olivine and ilmenite [2]. Our petrologic studies include determination of plagioclase compositions for the two major clast types and matrix grains, which we report here.

Plagioclase Compositions: Plagioclase compositions have been determined for 31 mafic clasts and 44 matrix grains in serial thin sections: USNM 897-12 and USNM 897-13. The compositions reported are for individual analyses as the grains are not homogeneous. Matrix grain fragments are 300-1500 μm in size. Compositions of matrix grains vary from $\text{Ab}_{6.0-28.6}$; $\text{Or}_{0.2-2.7}$; half are $\text{Ab}_{\leq 10}$; $\text{Or}_{\leq 0.4}$. Compositions for plagioclase grains in clasts cover virtually the same range: $\text{Ab}_{5.4-25.2}$; $\text{Or}_{0.2-2.3}$. Microgabbro clasts have in general more calcic plagioclases and more restricted ranges in composition than the basalt clasts. However, there is substantial overlap in compositional ranges of plagioclase between the two clast types. A characteristic of Pasamonte plagioclase analyses that pass all other “quality assurance” filters is that many of them have Si in excess of that calculated for stoichiometric plagioclase with the measured Ca, Fe, Mg, Na and K contents. Furthermore, there is a positive relationship between the percent deviation from Si stoichiometry and albite content of the plagioclase. Analyses with $\text{Ab}_{5.4-10.0}$ have molar Si within $\pm 1.5\%$ of stoichiometry, while the most sodic analysis, $\text{Ab}_{28.6}$, has a Si deviation from stoichiometry of 11.2%.

Discussion: Silica in excess of that required for stoichiometry was demonstrated in lunar mare basalts [e.g., 7], and was attributed to the solid solution of $[\text{Si}_4\text{O}_8]$ in plagioclase [e.g., 8, 9] based on experimental work in the anorthite-silica system [10]. Plagioclases from mare basalts show a trend of increasing departure from Si stoichiometry [7] (increasing molar $[\text{Si}_4\text{O}_8]$ content [8, 9]) with increasing albite content, which is what we observe for Pasamonte plagioclases. Similar departures from stoichiometry are not observed for terrestrial mafic igneous rocks [7, 9]. Mare basalt plagioclases show core-rim anorthite-albite zoning that is accompanied by increasing $[\text{Si}_4\text{O}_8]$ [9]. The trends in mare basalt plagioclases are interpreted as arising from a combination of decreasing temperature of formation, growth from a progressively more Si-rich liquid, and rapid growth causing delayed nucleation of plagioclase and silica [9]. Mare basalts crystallize pyroxene before plagioclase and this was considered to favor the importance of kinetic effects in excess silica substitution [9].

Basaltic eucrites are approximately co-saturated in pigeonite and plagioclase; for Pasamonte, plagioclase appears within 5 °C of pigeonite on the liquidus in melting experiments [11]. Thus, the crystallization path of the melt did not play a role in excess silica substitution. The mafic clast that shows the largest deviations from stoichiometry consists of numerous, very fine plagioclase grains enclosed in the margins of coarse pyroxenes that abut a mesostasis region composed of silica, ferroan olivine and ilmenite. This suggests that nucleation of the plagioclase was inhibited and that kinetic factors were important in engendering the excess silica substitution for this clast. Excess silica substitution does not appear to be common amongst eucrites. We have determined plagioclase compositions in 26 basaltic eucrites. Evidence for excess silica substitution has not been observed in any of them, with the exception of anomalous paired basalts Pecora Escarpment (PCA) 82502 and PCA 91007. In these meteorites, a maximum Si deviation from stoichiometry of only 5.0% at Ab_{20} is observed. Plagioclase grains in diogenite Lewis Cliff (LEW) 88011 have small departures from Si stoichiometry (up to 3%) correlated with Na content [12] consistent with excess silica substitution.

Key Finding: Compared to stoichiometric plagioclase, plagioclase grains in anomalous eucrite Pasamonte have excesses in Si that are correlated with their Na contents. This is due to $[\text{Si}_4\text{O}_8]$ solid solution as documented for mare basalt plagioclase [9]. Excess silica substitution in plagioclase is uncommon amongst basaltic eucrites pointing to differences in the crystallization history for Pasamonte.

References: [1] Metzler K. et al. (1995) *Planet. Space Sci.* **43**:499. [2] Mittlefehldt D. W. et al. (2017) *LPS XLVIII*, Abstract #1194. [3] Wiechert U. H. et al. (2004) *Earth Planet. Sci. Lett.* **221**:373. [4] Greenwood R. C. et al. (2005) *Nature* **435**:916. [5] Scott E. R. D. et al. (2009) *Geochim. Cosmochim. Acta* **73**:5835. [6] Sanborn M. E. et al. (2016) *LPS XLVII*, Abstract #2256. [7] Weill D. F. et al. (1970) *Proc. Apollo 11 Lunar Sci. Conf.* **1**:937. [8] Beaty D. W. and Albee A. L. (1978) *Proc. Lunar Planet. Sci. Conf. 9th* **1**:359. [9] Beaty D. W. and Albee A. L. (1980) *Am. Min.* **65**:63. [10] Longhi J. and Hays J. F. (1979) *Amer. J. Sci.* **279**:876. [11] Stolper E. (1977) *Geochim. Cosmochim. Acta* **41**:587. [12] Mittlefehldt D. W. et al. (2012) *Meteoritics Planet. Sci.* **47**:72.